MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

Tri-2 2016/2017

EPH7046 – OPTOELECTRONIC DEVICES

4th-March 2017
9.00 a.m – 12.00 p.m
(3 Hours)

INSTRUCTION TO STUDENT

1. This Question paper consists of 4 pages with 4 Questions only.
2. Attempt all the **FOUR** questions. All the questions carry equal marks and the distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

Question1

(a): Describe different type of modes in Laser Diodes.

[7 marks]

(b): Explain current-voltage characteristics in Light Emitting Diode (LED) with all relevant equations and graph.

[7 marks]

(c): What is the basic structure of a Fabry-Perot Laser Diode? Explain with proper diagram.

[5 marks]

(d): Describe the theory of Radiative Recombination and Light Absorption in semiconductors with Proper energy band diagrams.

[6 marks]

Question2

(a): A Si photodiode has an active light receiving area of diameter 0.4mm.When radiation of wave-length 700nm (red light) and intensity 0.1mW cm^{-2} is incident it generates a photocurrent of 56.6nA.What is the Responsivity and Quantum Efficiency(QE) of the photodiode at 700nm?

[7 marks]

(b): Briefly describe solar cell and justify the current-voltage characteristics of solar cell with proper diagrams.

[8 marks]

(c): Justify Noise in Charge-Coupled Device (CCD) with proper diagram

[5 marks]

(d): Briefly explain Schottky Barrier Infrared(IR) Imagers.

[5 marks]

Continued---

Question3

(a): Describe theoretically twisted nematic cells with proper diagram.

[7 marks]

(b): Consider an n-type semiconductors.The probability that a donor level E_d is occupied by an electron is $f_d = \dfrac{1}{1+\dfrac{1}{g}\exp\left(\dfrac{E_d - E_F}{kT}\right)}$

where k is the Boltzmann constant, T is the temperature, E_F is the fermi energy,and g is the degeneracy factor (in this case g = 2).

show that $n^2 + \dfrac{nN_c}{g\exp\left(\dfrac{\Delta E}{kT}\right)} - \dfrac{N_d N_c}{g\exp\left(\dfrac{\Delta E}{kT}\right)} = 0$

where n is the electron concentration in the conduction band, N_c is the effective density of states at the conduction band edge, N_d is the donor concentration and $\Delta E = E_c - E_d$ is the ionization energy of the donors.

[10 marks]

(c): Explain Mach-Zender modulator with proper diagram.

[8 marks]

Question4

(a): Give the explanation of Four-wave mixing with proper diagram.

[7 marks]

(b): Describe basics of optical modulators with proper diagram.

[9 marks]

(c): Consider a Si pn-junction with equal doping, $N_a = N_d = 10^{18}\,cm^{-3}$ or $10^{24}\,m^{-3}$ .The cross-sectional area is 1 mm^2 .The minority carrier recombination times are $\tau_h = \tau_e = 23.8ns$. Calculate the forward recombination current when the voltage across the pn-junction is 0.5V.Compare this with the diffusion current.

[9 marks]

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Appendix A
Useful constants:

Speed of light:	$c = 3.0 \times 10^{8}$ m/s
Electronic charge:	$e = 1.6 \times 10^{-19}$ C
Planck's constant:	$h = 6.63 \times 10^{-34}$ Js
Permittivity in vacuum:	$\varepsilon_o = 8.85 \times 10^{-14}$ F/cm
Permeability in vacuum:	$\mu_o = 4\pi \times 10^{-7}$ H/m
Free electron mass:	$m_o = 9.11 \times 10^{-31}$ kg
Boltzmann's constant:	$k = 1.3806 \times 10^{-23}$ J/K
Thermal voltage:	$V_t = kT/e = 0.0259$ V

End of paper---